confronted with, because of the fact that, owing to public opinion, he can not enforce stringent and drastic measures to guard against the stealing of such things as chickens and eggs.

One further fact to which we wish to call attention here has to do with the character of the barring exhibited by certain of the F_2 birds. In the paper describing the F_1 birds special stress was laid on the fact that the barring in these birds was not of such fine quality from the fancier's standpoint as in pure Barred Rocks. No one familiar with good specimens of that breed could ever mistake a barred F_1 bird for a pure Rock. In certain of the F_2 birds this is not the case. Certain of the F_2 matings produced birds which had a much finer, sharper and cleaner cut barred pattern, or, to adopt a technical expression, a "snappier" barring than any pure Barred Rock in the Station stock. In other words, it appears that though the heterozygous nature of the F_1 birds was apparent in their external characters, the segregation of barred pattern in the F_2 generation was not merely perfect, but, to speak paradoxically, was more than perfect, *i. e.*, produced something better than existed in the parent stock. It may be said, in passing, that the same thing is true with reference to comb types. In the F_1 generation there were very few *perfect* pea combs, from the fancier's standpoint. In the F_2 generation where pea combs segregated out relatively many of them were of fine showroom quality, and relatively few were badly defective or intermediate between pea and single. The relation of the individuality of the birds bred to the quality of the segregation products furnishes an exceedingly interesting and important problem.

One further point needs mentioning. In the F_1 generation the male birds produced by the cross of B.P.R. ♂ × C.I.G. ♀ and its reciprocal were all alike in gametic formula and external appearance. The F_2 results indicate that the same results were obtained with F_1 males from the cross B.P.R. ♂ × C.I.G. ♀ as with those obtained from the cross C.I.G. ♂ × B.P.R. ♀. These two kinds of males were, in other words, equivalent in fact as well as in theory.

In later papers the details of the results here briefly reported will be presented, and a discussion of the different types of non-barred birds and the laws of their appearance entered upon.

By way of summary it may be said that experiments involving 670 adult birds in the F_2 generation, arising from all possible matings of F_1 birds *inter se* and with the parent pure breeds (Barred Plymouth Rock and Cornish Indian Game) give results in regard to the inheritance of the barred color pattern which are in accord with a Mendelian hypothesis of sex-limited inheritance of this character, developed along lines originally suggested by Spillman.

Raymond Pearl
Frank M. Surface
Biological Laboratory,
Maine Experiment Station,
November 21, 1910

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

The eleventh annual meeting of the Astronomical and Astrophysical Society of America was held at Harvard College Observatory, Cambridge, Mass., on August 17, 18 and 19. The society was welcomed to Cambridge by Professor E. C. Pickering, both in his capacity as president and as director of the observatory. Among those present were more than a score of foreign astronomers and physicists, who had come to this country for the purpose of attending this meeting and later that of the International Union for Cooperation in Solar Research at Mount Wilson in California. The complete list of those in attendance is as follows: Miss Allen, Miss Breslin, Miss Cannon, Miss Carpenter, Miss Cushman, Mrs. Fleming, Miss Harwood, Miss Hayes, Miss Leavitt, Miss Leland, Miss O'Reilly, Miss Walker, Miss Waterbury, Mrs. Whitin, Miss Whiting, Messrs. Apple, Archer, Backlund, Bailey, Barton, Bell, Belopolsky, L. Brown, L. Campbell, Cirera, Coit, Comstock, Cortie, Cotton, Dinwiddie, C. L. Doolittle, Douglass, Dugan, Duncan, Dyson, Edwards, Eichelberger, Fabry, Fisher, Fowler, Gimenez, Hepperger, Hills, Humphreys, Hunt, Hussey, E. S. King, Larmor, C. Lundin, C. A. R. Lundin, Man-

son, Metcalf, Milham, D. C. Miller, S. A. Mitchell, Newall, Parkhurst, Peirce, Peters, E. C. Pickering, W. H. Pickering, Plaskett, J. M. Poor, Pringsheim, Ricco, Roe, Rotch, Russell, Rydberg, Schwarzschild, Schlesinger, Skinner, Stebbins, Stetson, Turner, Updegraff, Upton, Very, Wendell, Whitman, Willson, Wolfer and W. L. Wright.

The following persons were elected to membership: Miss Leah Brown Allen, Wellesley, Mass.; Professor A. T. C. Apple, Lancaster, Pa.; Father Peter Archer, S.J., Georgetown University; Dr. Oskar Backlund, Pulkowa, Russia; Miss Louise Brown, Wellesley, Mass.; Professor Robert E. Bruce, Boston University; Mr. A. J. Champreux, Berkeley, Cal.; Professor Wilbur A. Coit, Acadia University, Wolfville, N. S.; Professor A. E. Douglass, University of Arizona; Dr. J. C. Duncan, Harvard University; Mr. F. W. Dyson, Royal Observatory, Greenwich, England; Mr. Sturla Einarsson, Berkeley, Cal.; Mr. Charles Grosjean, Omaha, Nebraska; Miss Margaret Harwood, Littleton, Mass.; Miss Ellen Hayes, Wellesley, Mass.; Professor Josef v. Hepperger, Vienna, Austria; Mr. Charles John Hudson, Clinton, Mass.; Miss Jennie B. Lasby, Pasadena, Cal.; Mr. C. A. Robert Lundin, Jr., Cambridgeport, Mass.; Mr. P. G. Nutting, Washington, D. C.; Mr. W. F. Meyer, Berkeley, Cal.; Professor W. I. Milham, Williamstown, Mass.; Miss Mary Proctor, New York City; Mr. R. F. Sanford, Mt. Hamilton, Cal.; Professor Karl Schwarzschild, Potsdam, Germany; Mr. Elihu Thomson, Swampscott, Mass.; Professor H. H. Turner, Oxford, England; Mr. Percy F. Whisler, Urbana, Ill. It will be noticed that this list contains the names of several foreign astronomers, a gratifying innovation that is likely to prove of considerable importance to the society.

Most of the sessions were as usual devoted to the reading and discussion of papers, but time was found for several pleasant and instructive excursions to points of scientific interest in the vicinity of Cambridge; thus on the afternoon of the seventeenth a visit was paid to the meteorological observatory at Blue Hill, where Director Rotch exhibited the equipment and explained the work of the institution. On the afternoon of the eighteenth the society went in a body to the Whitin Observatory of Wellesley College and on the nineteenth to the Students' Observatory of Harvard College; these two visits were of particular interest to those who are engaged in teaching, as Professor Willson and Miss Whiting, who are in charge of these observatories, have highly developed the "laboratory method" in astronomy. In addition ample opportunity was given to the members to examine the equipment of Harvard Observatory itself, and for this purpose the whole staff of the observatory very kindly put their time at the disposal of the visitors.

The following papers and reports were read at the various sessions:

Some Preliminary Results deduced from Observed Radial Velocities of Stars: W. W. CAMPBELL. (Read by Mr. Plaskett.)

From the radial velocities of more than one thousand stars, observed for the most part at the Lick Observatory and at its southern station in Chile, the following results were obtained for the location of the apex of the sun's way:

Right ascension, $272°.0 \pm 2°.5$.
Declination $+ 27°.5 \pm 3°.0$.
Velocity of the sun in space, 17.77 km.

The last is somewhat smaller than was expected in view of the author's earlier value from 280 stars and that of Hough and Halm. The data could, however, not be made to yield a sensibly greater value; 330 stars of spectral types O, B, A and F (up to F4) yielded 17.69 km., while 704 stars of types F5 to G, K and M gave 17.96.

The stars were tabulated with regard to spectral types and it was found that their velocities increase as the type advances, those of B type having an average velocity of 9.0 km.; A type, 10 km.; F, 14 km.; G and K, 15 km., and M, 16.5 km.

A study of 280 velocities made by the author in 1900 had indicated a progressive decrease in velocity with increasing brightness; a similar study of the fourfold more extensive material now at hand does not confirm the earlier result, which seems to have been due to the larger proportion of first-type spectra in the earlier data.

The author showed that Kapteyn's discovery of systematic drifting, deduced from the study of proper motions, was clearly and strongly confirmed by the radial velocities. Stars in the neighborhood of Kapteyn's vertex and antivertex appear to have velocities about 33 per cent. greater than stars that are about 90° from these points.

A study of radial velocity in connection with proper motions indicates that stars of different spectral types and likewise of different magnitudes are more thoroughly mixed, that is more nearly equal in distance, than has previously been supposed; and that the brighter stars, down to the fifth magnitude, are nearer to us than the formulæ for mean parallaxes would place them.

The systematic study of spectroscopic binaries led to interesting conclusions which have since been published in Lick Observatory Bulletins, Volume 6, p. 17.

Items as to New Spectroscopic Binaries: EDWIN B. FROST and OLIVER J. LEE. (Read by Mr. Parkhurst.)

Particulars were communicated regarding the following twenty spectroscopic binaries, recently detected at the Yerkes Observatory: σ Andromedæ, B. D. 59°.146, 86 ρ Tauri, μ Eridani, ω Orionis, ν Geminorum, 42 Camelopardalis, ϕ Germinorum, γ Cancri, θ Hydræ, σ Leonis, 23 Comæ, η Coronæ, ι Serpentis, γ Coronæ, π Serpentis, 68 Ophiuchi, 13 Vulpeculæ, 33 Cygni, 16 Lacertæ.

Probable Errors of Radial Velocity Determinations: J. S. PLASKETT.

This paper presents the results of the measures of a number of plates of the same star with three different dispersions, a three-prism spectrograph with a long focus and a short-focus camera and a single-prism spectrograph, whose linear dispersions are approximately as 3, 1½, 1. It is shown that the probable error of a plate by no means increases proportionately with decrease of dispersion, but that, so far as these results go, probable error is only increased about 40 per cent. for a decrease of dispersion from 3 to 1. A discussion of these results is followed by a consideration of the effect of change of spectral type, with the consequent change in the number and quality of the lines measured, upon the errors of radial velocity determinations. A tabulation of the probable errors of single plates obtained in the determination of numerous spectroscopic binary orbits shows how closely these errors depend upon the quality of the lines for measurement.

Visual and Photographic Magnitudes, Colors and Spectral Types of the Stars to Magnitude 7.5 in the Zone between 73 and 77 Degrees North Declination: J. A. PARKHURST.

The photographic determination of star-colors and their relation to spectral types was begun in 1906 at the Yerkes Observatory by F. C. Jordan and the writer. In March, 1908, work was begun on a zone centered at + 75°, with the idea of extending it to the pole. The present paper describes the results for the stars between + 73° and + 77°, 290 in number. All the work was photographic, using a Zeiss doublet of 145 mm. aperture and 814 mm. focal length. The photographic magnitudes were taken from Seed plates exposed 6 mm. from the focus, giving extra-focal images 1.2 mm. in diameter. The opacity of these images was measured with a Hartmann surface photometer so calibrated as to give magnitudes on an absolute scale. The "visual" magnitudes were obtained from micrometer measures of the diameters of focal images taken on Cramer trichromatic plates, using a "visual luminosity" filter. The magnitudes are based on the system of the Potsdam *Photometric Durchmusterung.* The spectral types were estimated from plates taken with a 15° objective prism over the same doublet. The Harvard classification was used. The probable error of a catalogue magnitude is ± 0.03 for the photographic, and ± 0.04 for the visual values. The color-perception of the plates is a little less than the Potsdam, and about equal to the Harvard catalogues. The color-spectrum curve is steeper than that given in Vol. 59 of the *Harvard Annals.*

An Independent Method of Determining the Extra-telluric Solar Radiation: FRANK W. VERY.

Static methods in actinometry are at present in disrepute on account of the difficulty of obtaining accurate values of the instrumental corrections. The proposed method overcomes this objection by completely eliminating the most troublesome of these corrections. There remain only theoretical difficulties, and some of these will continue to exist by whatever method we may approach the problem. A recent new determination of the melting point of platinum by Day and Susman fixes its value at 2048° C. Abs. within 5°. If we expose a strip of thinnest platinum, coated with platinum black, to the solar rays at the focus of a condensing mirror, and gradually increase the aperture of the mirror by opening an iris diaphragm, having first heated the foil until the conduction into the supports has assumed a steady state, which will require about two minutes, a point is reached where a further increase of the aperture will almost instantly melt the platinum. The experiment avoids the necessity of applying an uncertain correction for loss of heat by convection, because, owing to the viscosity of air at high temperatures and the slow motion of the air, the loss by convection in the time required to melt the platinum is negligible. The temperature of the environment need not be considered, since radiation at ordinary temperatures is insignificant compared with that of melting platinum. The platinum black passes to bright platinum in melting, but lasts long enough for the purpose of the comparison, which gives the means of confronting for an instant surfaces which are more nearly

comparable than those of an ordinary actinometer and the sun. The experiment has been performed in a preliminary way by Professor J. M. Schaeberle, using a silver-on-glass concave mirror of his own construction, as described by him in SCIENCE for December 20, 1907. Professor Schaeberle has communicated to the author details of the operation, which gives the following result: using Stefan's formula for total radiation of a black body with Kurlbaum's constant, the temperature of a "black" sun is 6563° C. Abs., and the solar constant = 3.05 calories.

On the Need of Adjustment of the Data of Terrestrial Meteorology and of Solar Radiation, and on the Best Value of the Solar Constant: FRANK W. VERY.

In this paper Professor Very first points out that owing to the complexity of the field of terrestrial meteorology and the uncertainty of some of its data, compromise and adjustment are necessary if we are to have a consistent theory. The great importance of the solar constant and the impossibility of observing it directly, demand unusual care; attention must be paid to the principle that the adopted value must not violate other facts of observation that rest on a firmer basis than the constant itself. The paper goes on to criticize certain phases of the work of Abbot and Fowle in volume II. of the *Annals of the Astrophysical Observatory of the Smithsonian Institution,* more especially their virtual assumption that the transmission of telluric radiation by our atmosphere varies in proportion to an experimental coefficient raised to a certain power depending upon the mass of aqueous vapor in the transmitting column. As a consequence of this and some other points of hardly less importance, Professor Very believes that the value of the solar constant deduced by the Smithsonian observers is much too small and that the true value exceeds three calories; and further that this higher value of the constant reconciles meteorological and astrophysical data which would otherwise be incompatible. It is not possible within the narrow limits here allowable to summarize adequately this important paper, which it is hoped will soon be published in full.

The Lick Observatory Photographs of Halley's Comet: H. D. CURTIS. (Read by Professor Comstock.)

In the interval between September 12, 1909, and July 7, 1910, 370 photographs were secured on 95 nights; 206 of these were taken with the Crossley reflector, 120 with either a 5½-inch or a 6-inch portrait lens, and 44 with short-focus camera lenses. These auxiliary cameras were all mounted on the tube of the reflector and the guiding was accomplished by means of a 3.5-inch finder of 211.5 inches focal length. The Crossley plates are of great interest in the amount of material they furnish for the study of the envelopes and other features in the head, which varied greatly from night to night. Photographs taken with the smaller cameras are chiefly useful in a study of the tail, which was photographed up to 28° from the head.

The Society's Expedition to Hawaii for Photographing Halley's Comet: FERDINAND ELLERMAN. (Read by Professor Comstock.)

After a short reconnaissance Mr. Ellerman selected a site on the south slope of Diamond Head, five miles southeast of Honolulu. The first photograph was secured on April 14, 1910, and the last on June 11. In all 58 negatives were secured with the 6-inch Brashear doublet and 11 with a 2¼-inch Tessar, on 36 different dates. The paper was illustrated with many slides that brought out very clearly the interesting changes in the comet's appearance that occurred toward the end of May and early in June.

On the Motion of the Particles in the Tail of Halley's Comet on June 6, 1910: E. E. BARNARD. (Read by Mr. Parkhurst.)

The photographs on this date show a discarded tail drifting away from the comet. The rear end of this receding tail was measured with respect to the head on three photographs taken respectively at Williams Bay, Honolulu, and Beirut, Syria. The last two were made by Mr. Ellerman and Mr. Joy. The Greenwich mean times of these photographs are June 6^d 15^h 49^m, 20^h 4^m and 30^h 58^m.

Williams Bay *minus* Honolulu, motion per second from head, 23.0 miles.

Williams Bay *minus* Beirut, motion per second from head, 33.5 miles.

Honolulu *minus* Beirut, motion per second from head, 37.4 miles.

The comet's motion away from the sun was 16.6 miles per second. Hence the motions of the mass with respect to the sun were, respectively, 39.6, 50.1 and 54.0 miles per second. These show a decided acceleration of the motion of the mass.

Some Results with a Selenium Photometer: JOEL STEBBINS.

After a considerable amount of experimenting,

the selenium photometer has been perfected so that bright stars can be measured more accurately than by either visual or photographic methods. With a selenium cell attached to the 12-inch refractor, an exhaustive study of the light-curve of Algol has been made, with special attention to the constancy of the light at maximum. It has been found that Algol is a star of continuous variation, the light-curve showing both a secondary minimum and changing light between minima. From these observations new elements have been derived, which indicate that the companion, which has often been considered a dark body, in reality gives more light than our own sun; and in addition is much brighter on the side which is turned toward Algol, due presumably to the heating effect of the intense radiation which is received from the primary. A complete account of this work is to be published in the *Astrophysical Journal*.

Note on the System of Algol: R. H. CURTISS. (Read by Professor Stebbins.)

Observations employed in a paper by the author, published in the *Astrophysical Journal*, **28**, 150, suggest a variation in the period of revolution of the center of mass of the eclipsing pair of Algol, about the center of mass of the system. Tisserand's hypothesis as to the rotation of the line of apsides of the orbit of the eclipsing pair is still consistent with the facts. On the basis of this hypothesis and Chandler's elements with Vogel's well-known data, the period of rotation of Algol must lie between 0 days and 4.23 days with a probable value equal to the light period. Rejecting the assumptions of Vogel and Tisserand, limiting values of the oblateness of figure of the eclipsing stars are computed, the identity of the rotation and light periods being assumed. Certain constants of the system are computed on the basis of Vogel's data.

A new Sixteen-and-one-fourth-inch Doublet: JOEL H. METCALF.

This doublet has been constructed by the writer and is now mounted at the Harvard Observatory. The glass is of the general form of the Petzval-Voigtlander type working with an aperture of f 5.5. Its special features are (1) the use of dense flint (Series O of Parra Mantois) instead of the light flint usually employed in these constructions. This reduces the steepness of the curves, the thickness of the lenses and the resultant curvature errors. The glass is very transparent and free from veins as well as finely annealed. (2) Astigmatism has been almost entirely eliminated so as to secure round star images suitable for measurement all over the field. This has been done even at the expense of some flatness of the field which has been corrected in another way. (3) The careful elimination of coma. This has been done by theory and the residual amount neutralized by the spacing of the front and back combinations by actual experiment. (4) The spherical aberration of the second and fourth orders has been eliminated by theory and the careful spacing of the lenses of the front combination. This has been done for the spectrum in the region of the G line by the use of nearly monochromatic light in testing. The fourth order aberration has been eliminated by local polishing or parabolizing the front surface of the first crown lens. The errors remaining are a slight curvature of the field which has been practically eliminated by Professor Pickering by the use of plates mechanically bent to the proper curvature. The one remaining appreciable error in a field of eight or ten degrees is the secondary color correction which is inherent in all lenses made of the ordinary crown and flint glass. In a lens of such great absolute and relative aperture this error is quite marked, as the enlargement of the images of bright stars shows. Unless the use of other glasses will materially reduce this secondary spectrum it would seem useless to construct doublets of greater size with such large relative aperture, for the effect would be to increase the scale of the picture without giving greater space-penetrating power.

Solar Prominences Photographed with the Rumford Spectroheliograph of the Yerkes Observatory: FREDERICK SLOCUM. (Read by Mr. Parkhurst.)

This paper consisted of: (1) A series of photographs of a large quiescent prominence observed from March 4 to April 28, 1910 (two rotations of the sun). Maximum height $106'' = 77{,}000$ km. Maximum lateral extent, 47° of the sun's limb = 57,000 km. (2) A series of photographs of a very active prominence observed on March 25, 1910. Beginning as a small insignificant cone, this prominence developed rapidly, and in a few hours vanished at a height of $7'.4 = 320{,}000$ km., after having passed through a variety of fantastic shapes. (3) Miscellaneous photographs of prominences obtained at the Yerkes Observatory during the past few years.

An Instrument for Rapidly Solving Spherical Triangles: F. W. DYSON.

This has been made by Mr. W. B. Blaikie, of Edinburgh; it is very simple and ingenious, and is useful when one is only working to half degrees. He has lithographed on two sheets of celluloid stereographic projections of parallels and meridians, the poles in each case being on the circumference. One of these sheets is fixed and the second, which is placed above it, can be turned about a pin at the center. In this way five parts of the triangle can be read off at once.

An Interesting Spectroscopic Binary, 96 Herculis: S. A. MITCHELL.

While at the Yerkes Observatory in the earlier part of this summer, a spectroscopic binary of more than usual interest was found in 96 Herculis, a star of 5.1 magnitude, I 5 type, with many good lines. The first plate measured showed the lines to be triple and the ternary character of the star has been abundantly verified. The results of measures from two plates are as follows:

Plate taken on June 6, 1910.

Component I., radial velocity = — 26 km. from 18 lines.

Component II., radial velocity = + 25 km. from 6 lines.

Component III., radial velocity = + 62 km. from 9 lines.

Component I. is very strong, II. and III. are sharp but faint.

Plate taken on June 24, 1910.

Component A, radial velocity = — 85 km. from 8 lines.

Component B, radial velocity = — 19 km. from 16 lines.

Component C, radial velocity = + 33 km. from 8 lines.

Components A and C are faint, but sharp; B is strong.

Changes are rapid, the period (if such can be said to exist in a three-body system) is a few days.

On the Accuracy of the Star Positions of the Harvard Sky: H. H. TURNER.

The Harvard Sky consists of fifty-five plates, each covering about thirty degrees square. The scale is rather less than one tenth that of the Astrographic Catalogue, a réseau interval of five millimeters corresponding to about fifty-two minutes at the center of the field. The plates are therefore not intended for giving accurate positions, but it is convenient to know what kind of accuracy is obtainable from the plates, and further it is of interest to know the optical distortion of a lens covering such a wide field. Two plates have been partially measured with some care, the measures being confined to the neighborhood of rectangular axes through the plate center. The first plate (R. A. $6^h\ 0^m$; Decl. 0°) was measured some years ago and an outward optical distortion of $0''.024\ r^3$ was indicated, r being the distance from the plate center expressed in réseau intervals. The second plate was measured recently by Mr. G. H. Hamilton, who used a much larger number of stars than were used before. The value for the distortion was found quite independently to be $0''.030\ r^3$ in one coordinate and $0''.036\ r^3$ in the other. The uncertainty of the determination is due to the confusion with the scale value: for the differences may be written (say) $\pm 0''.006\, r(r^2 - 10^2)$; which does not exceed $2''.3$ between $r = 0$ and $r = 17$. The point on the plate from which this distortion radiates may be approximately identified as follows: Let the coordinates be (a, b) so that the displacement in x is $k(x-a)\{(x-a)^2 + (y-b)^2\}$. The terms in x^2 and xy can arise from tilt of plate; but the term $-kay^2$ can not arise from tilt and enables us to find a. Similarly b can be found from the displacement in y. When this distortion and a slight tilt of the plates are allowed for, the resulting star measures agree closely with the calculated measures; which suggests that if large plates could be made sufficiently flat, large fields might be photographed with accuracy. This object might be attained as follows: Let a large glass surface be carefully planed and ruled with réseau lines; and placed in the focus of a wide angle lens. Several small plates could be placed film down on this surface, to receive the images of the stars and of the portion of the réseau which they covered. They could be developed and measured as separate plates, all accurately connected by the réseau lines of the matrix.

The Photometric Magnitude of Eros in 1903: S. I. BAILEY.

The variability in light of Eros was announced by E. von Oppolzer in 1901. At this time the range of variation was said to be two magnitudes. Observations somewhat later at the Harvard Observatory, by Professor Wendell, showed that at times the range of variation was very small or entirely lacking. At the suggestion of the director of Harvard Observatory, the writer undertook an extensive study of the changes in light

of Eros, at Arequipa, during the opposition of 1903. The instrument employed was one of the Rumford photometers devised by Professor E. C. Pickering and described by Mr. J. A. Parkhurst in the *Astrophysical Journal*, **13**, 249. Observations were carried on from March 30 to August 19, 1910. On many nights the observations were made to cover the full double period of the light changes. The results give a mean period of 5.270 hours, for the double period, or, since the two halves of the curve appear to be precisely equal, a period of 2.635 hours. The period would change by a small amount during this time, but the above period satisfies well all the observations. The range of variation appeared to vary from five tenths to eight tenths of a magnitude, the mean being about six tenths. The brightness of Eros during these observations varied from about magnitude 11 to magnitude 13.5.

The Division Errors of the Nine-inch Transit Circle of the Naval Observatory, and the Effect upon the Division Errors of Refilling the Divisions: W. S. EICHELBERGER.

Two independent determinations of the division errors were made by Professor Eichelberger for each of the 10,800 graduations. A comparison of these indicates a probable error of 0″.04 for the 2′ marks. For the degree marks the probable error is 0″.018. These determinations were made after the graduations had been refilled; to determine whether they would apply to the 20,000 observations previously made, the observed corrections to the ephemeris declinations of the sun were collected and it was shown that the recently determined division errors were in all probability applicable. A similar result was obtained by discussing the earlier observations of 400 zodiacal stars, and computing the probable error of a declination (1) when the same division had been used for the same star, and (2) when different divisions had been used. These became practically the same only after the recently determined division errors had been applied, and indicated that these errors could have been only slightly altered, if at all, by the refilling of the marks. Professor Eichelberger finds that this circle, like those of the 6-inch transit-circle of the Naval Observatory, shows a periodic error in the 2′ marks that repeats itself every 10′.

The Eclipsing Variable u Herculis: FRANK SCHLESINGER and ROBERT H. BAKER.

In the usual case presented by spectroscopic binaries the masses of the two components, and therefore their densities, remain indeterminate. This is because (1) the inclination of the orbit can not be computed from measures of the radial velocities alone; and (2) it is necessary to know the ratio of the two masses involved before either becomes determinate. Both of these obstacles are removed in the case of such of the eclipsing variables for which both spectra appear upon the plates. Among the stars readily accessible to present-day instruments there are only three that fulfill these conditions: β Lyræ, V Puppis and u Herculis, and only for the last have the necessary observations been made. A discussion of these data shows that the two stars must be very nearly the same size, but that one has a density 2.6 times that of the other and is about 2.5 times as bright. These results have an important bearing on questions of double-star evolution. It was also shown that if the parallax were accurately determined, it would be possible to state whether the surface brightness of these helium stars is greater or less than that of our sun, a question that has been the subject of considerable debate in recent years. This paper will soon appear in volume II. of the Publications of the Allegheny Observatory.

The Rotation of the Sun for Different Substances in the Reversing Layer: FRANK SCHLESINGER.

A series of spectrograms were secured in the fall of 1909 with the new Porter spectrograph of the Allegheny Observatory. This is fed by a vertical cœlostat that forms part of the Keeler reflecting telescope. The dispersing piece is a large Michelson grating with 500 lines to the millimeter. The photographs were taken in the third order and yield a linear dispersion of 0.82 millimeter to the Ångström. Thirty-seven good lines from λ 4059 to λ 4147 were selected and the displacements due to rotation measured on eighteen plates. No difference from the mean greater than 2.4 per cent. was found and a discussion of the residuals made it very probable that differences due to rotation must be much smaller than this. The results showed no systematic tendency for the various lines due to the same substance. There seemed to be a small systematic increase of displacement with increase of wave-length, and the recent observations at Mount Wilson seem to show the same tendency.

The Orbit and Spectrum of o Persei: FRANK C. JORDAN. (Read by Professor Schlesinger.)

The spectrum of the principal star is of the type B 2, and that of the secondary seems to be

an exact duplicate of the primary except as to brightness. The orbit was computed from seventy plates obtained at the Allegheny Observatory. Ten lines are the maximum number measured for the primary, though twenty-eight others are distinct enough for an approximate determination of their positions. Only seven lines of the secondary can be measured even on the best plates. The ratio of the mass of the brighter star to that of the fainter is 1.43. If the surfaces of the two were of the same brightness per unit area, and the densities the same, the difference in mass would imply a difference of but 0.27 magnitude, which is undoubtedly too small; therefore the secondary is either denser, or its surface brightness is less. The point of special interest in this star is the fact that the calcium lines H and K show constant velocity. K is measurable on sixty plates, from which is derived a mean velocity of $+12.4$ km. with a probable error of ± 4.27 km. for an average plate, while the probable error of the mean is ± 0.55 km. If instead of Rowland's wave-length of 3933.825 we use the mean derived from seven first type stars, 3933.768, the velocity becomes $+15.4$ km. If we use the value derived by St. John at Mt. Wilson, 3933.667, the velocity is increased to $+25$ km. As the velocity of the center of mass of the system is $+18.46$ km. it is impossible to say whether the velocity of the calcium vapor is the same or not, but it can not be much different. The H line of calcium gives a velocity of $+18.4$ km. or $+29.4$ km. depending upon whether we adopt Rowland's or St. John's wave-length. This line is a difficult one to measure because of the proximity of the diffuse Hϵ line, and this may account for the difference between its velocity and that of the K line. This paper is to be published in volume II. of the Publications of the Allegheny Observatory.

The Spectrum of the Chromosphere and the Application to it of some Recent Laboratory Investigations: WALTER S. ADAMS and HENRY G. GALE. (Read by Professor S. A. Mitchell.)

The first part of this paper is a continuation of the work of Hale and Adams, *Astrophysical Journal*, **30**, 222, on the photography of the flash spectrum without an eclipse. The number of lines obtained on these plates compares favorably with that afforded by eclipse plates, being much richer in the red but not so rich in the blue. About 97 per cent. of the bright lines can be identified with dark lines in Rowland's table; of the remaining 3 per cent. a few are due to helium. A marked feature of probably *all* the bright chromospheric lines is the tendency to double reversal as the sun's limb is approached; out farther they assume the character of simple bright lines. The enhanced lines, as compared with the arc lines, appear with much greater intensity as bright lines in the chromosphere than as dark lines in the ordinary solar spectrum; this agrees with the previous results of Lockyer, Evershed, Dyson and others. An attempt was made to identify the coronal line at $\lambda\, 5303.26 \pm 0.15$; the photographs show a well-marked line at $\lambda\, 5303.36$, but it is probable that this is coincident with the dark line at $\lambda\, 5303.401$ in Rowland's tables.

The second part of the paper is concerned with an investigation of the spectrum of the electric spark under pressure, made by Mr. Gale at the Pasadena laboratory. In the case of titanium it was found that in the region around $\lambda\, 4300$ the arc lines become completely reversed under pressures of five or six atmospheres while the enhanced lines remain bright. On plates taken at longer wave-length, however, some of the arc lines do not reverse, and in general the proportion of unreversed lines increases with the wave-length; this accords with Hale's result in *Astrophysical Journal*, **15**, 227. Similar results have been obtained for iron and chromium, except that higher pressures seem to be necessary to produce the maximum number of reversals. The authors then apply these results to the spectrum of the chromosphere as follows: Fabry and Buisson have shown that the pressure in the sun's reversing layer is between five and six atmospheres, which is the pressure used for most of the above laboratory experiments. We should accordingly expect that the enhanced lines will appear bright in the chromosphere while most of the arc lines remain dark, and this accords with the observed facts. Moreover, as we pass to the longer wave-lengths both the chromosphere and the plates of the spark spectrum taken in the laboratory show an increasing number of arc lines that do not reverse.

Some Results of the Study of the Spectra of Sirius, Procyon and Arcturus with High Dispersion: WALTER S. ADAMS. (Read by Mr. Plaskett.)

The material discussed by Mr. Adams in this paper consists of six plates of Sirius extending from $\lambda\, 4200$ to $\lambda\, 6600$, four of Procyon from $\lambda\, 4200$ to $\lambda\, 4900$, and nine of Arcturus from $\lambda\, 4300$ to $\lambda\, 6600$. These were secured with an auto-collimating prism spectrograph of 18 feet

focal length, yielding much higher linear dispersion than is usually employed in stellar work. The spectrograph was placed in a constant temperature-room and was fed by the 60-inch reflector of the Mount Wilson Observatory in the coudé form. These spectrograms were studied with a view to obtaining some knowledge of the pressures in the atmospheres of these stars. For this purpose the relative shifts with respect to an iron arc comparison spectrum were measured for the enhanced lines and also for the arc lines. The basis for this distinction is Mr. Adams's earlier work on the displacements, in all probability due to pressure, of lines at the limb of the sun; in this work he had found that the large displacements were as a rule associated with the enhanced lines, and small displacements with arc lines. For the three stars studied Mr. Adams finds:

Sirius,	enhanced lines *minus* arc lines	+ 0.014 Å
Procyon,	" " " " "	+ 0.009
Arcturus,	" " " " "	+ 0.001

Furthermore in Arcturus, whose spectrum closely resembles that of a sun-spot, it was found that only the iron lines show a shift in the positive direction, that is 0.006 Å toward the red; while the lines of nickel, titanium, vanadium, magnesium, calcium and hydrogen were in this order shifted toward the blue, hydrogen most of all. The principal inferences that the author draws from these results are that the cause of these systematic shifts in stellar spectra is the same as that which is effective at the limb of the sun, and that accordingly in all probability they are due to pressure. On this basis it becomes possible to compute the pressures in the atmospheres of these stars as compared with that of our sun. For Sirius this comes out twelve atmospheres (terrestrial) greater than that of the sun, and for Procyon seven atmospheres. For Arcturus an arrangement of the different gases similar to that in the sun is indicated; hydrogen, calcium and magnesium being at the level of low pressures and iron in the region of high pressures.

Note on the Spectrum of D. M. + 30° 3639: WALTER S. ADAMS. (Read by Professor Hussey.)

In 1892 Campbell found this star, whose magnitude is 9.3, to be surrounded by a hydrogen atmosphere 5″ in diameter. With a one-prism spectrograph (attached to the 60-inch reflector) and an exposure of 150 minutes, Mr. Adams succeeded in securing a satisfactory spectrogram of this faint star. The hydrogen lines from $H\beta$ to $H\zeta$ are visible and extend beyond the continuous spectrum by an amount that precisely corresponds to Campbell's estimate of 5″. The bright line at λ 4068 also extends outward about 4″; the origin of this line is unknown. This is also true of the extremely bright band at λ 4652, which does not extend beyond the continuous spectrum. A less satisfactory spectrogram had been obtained on an earlier evening; and a comparison of the two indicates that the velocity of the star is probably variable.

Note on D_3 in the Spectrum of Prominences: JENNIE B. LASBY. (Read by Miss Whiting.)

No photographic determination of the wave-lengths for the two components of D_3 in the sun appears to have been published. Four plates were secured by Mr. Adams on August 28 and December 15, 1908, when large prominences were visible; these were measured by Miss Lasby and also by Mr. Adams, and the wave-lengths were determined as 5875.841 and 5876.190, which are in good agreement with Mohler and Jewell's visual observations of the sun and also with their laboratory measures. Miss Lasby advances reasons against the supposition that D_3 is present as a dark line in the ordinary solar spectrum.

On the Determination of the Elements of Algol Variables: HENRY NORRIS RUSSELL.

In the first approximation, an Algol variable may be assumed to consist of two spherical stars, each of uniform surface brightness, revolving in a circular orbit. If the eclipse is total, that is, if there is a constant period at minimum, the actual brightness of each of the stars is at once known. Three unknowns have then to be found: the radius R of the eclipsing star, in terms of that of the orbit; the ratio κ of the radius of the eclipsed star to that of the other; and the inclination i of the orbit. Let θ be the orbital longitude of the eclipsing body, measured from the point of conjunction. Its value at the instant when any given percentage of the area of the eclipsed star is obscured may be found from the light-curve. If ρ is the apparent distance of the centers at this moment, we have from geometrical considerations $\rho^2 = \sin^2 i \sin^2 \theta + \cos^2 i$; and from the known eclipsed area $\rho = Rf(\kappa)$ where $f(\kappa)$ is a transcendental function, which can be computed for any given value of κ. Hence $R^2\{f(\kappa)\}^2 = \sin^2 i \sin^2 \theta + \cos^2 i$. From three such equations, corresponding to different percentages of obscuration, R and i may be eliminated, giving an equation of the form

$$\phi(\kappa)=\frac{\sin^2\theta_1-\sin^2\theta_2}{\sin^2\theta_2-\sin^2\theta_3}.$$

Tables have been prepared giving the values of $\phi(\kappa)$, taking θ_2 and θ_3 to correspond to obscurations of 60 and 90 per cent., and θ_1 to a number of values from 0 to 100 per cent. From each observed value of θ_1, κ may thus be determined. If the values so found are not in agreement, they may be improved by small modifications of the assumed θ_2 and θ_3. In this way a light-curve may be found which represents closely the whole course of the observations. When κ is known, R and i are very easily found. The whole computation of the elements can be made in less than an hour. When the eclipse is partial, the relative brightness of the two stars is also unknown. By assuming two or three values of this, light-curves may be computed as above, and the best value found by interpolation. If a secondary minimum exists, the eccentricity of the orbit and longitude of periastron may also be found by well-known methods.

Some Hints on the Order of Stellar Evolution: HENRY NORRIS RUSSELL.

Let it be assumed that a star grows denser as it advances in evolution; that it is in equilibrium under its own gravitation, without sensible external disturbance; and that the material of which it is composed behaves like the gases with which we are familiar. It has been shown by Ritter and others that such a star will grow hotter as it contracts (Lane's law) until its density reaches a critical value, probably between those of air and water, and nearer the latter. The temperature then reaches a maximum and later decreases. The most massive stars will reach the highest temperature at maximum. This is true of both surface and internal temperatures, the latter suffering the greater relative changes. Those stars that are hottest at any given time will, therefore, be more massive than the average. Stars whose surface temperature has a given value less than the maximum will be of two kinds—one early in evolution, of rising temperature, large diameter and low density; the other late in evolution, of falling temperature, small diameter and high density. The former will give out many times more light than the latter, on account of their greater size; and the lower the temperature, the more marked will be the differences between these two classes. As contraction proceeds, the stars, whose angular momentum is large, will break up into pairs, those formed earliest having the longest periods. The farther evolution proceeds, the greater will be the proportion of such pairs among the whole number of stars. Periods less than a day or two can not arise unless the density is already near or beyond the critical value defined above. Recent work on spectroscopic binaries has shown that the proportion of these is greatest for type B and least for types K and M; that short periods, especially those less than two days, are practically confined to types B and A; that the systems which give evidence of unusually great mass are almost all of type B; that the relation between period and eclipse-duration among the Algol variables (which are almost all of types B and A) shows that their densities are of the "critical" order of magnitude; and that the distribution of proper motions among the stars of given apparent brightness and spectral type shows (as Herzsprung has pointed out) that the redder stars from type G onward fall into two groups: one remote, of small proper motion and great luminosity, the other near us, of large proper motion and small luminosity. These two groups overlap for type F, but are more and more widely separated for the redder stars. The stars of the first kind, being visible at great distances, form a disproportionately large percentage of the naked-eye stars—from 85 per cent. for type G to 100 per cent. for type M, for which even the nearest of the stars of the second sort are invisible to the naked eye. The following interpretation of these facts is suggested: assuming, as is now generally believed, that stars of type B have the highest surface temperature, and those of type M the lowest, it appears that the stars of type B show just the characteristics which the hottest stars might be expected to have, and that they represent a stage near the middle of evolutionary history; and that the two groups, of different luminosity, among the redder stars, agree in characteristics with those of rising and falling temperature predicted by theory. The former, stars of small proper motion, may be regarded as earlier in evolution, the redder they are; and the latter, stars of large proper motion, as later in evolution, the redder they are. Since most of the redder naked-eye stars belong to the former group, the small percentage and long periods of spectroscopic binaries among these spectral types are accounted for. The scheme of evolution here suggested is presented tentatively, as a working hypothesis. Its fundamental conception is similar to that underlying Lockyer's classification—from which,

however, it differs radically as regards the criteria for distinguishing rising and falling temperatures.

Results from Photographic Photometry: EDWARD S. KING.

Early in the work the photometric laws were tested photographically; for example, the law of the square of the distance from the source of light was confirmed photographically by using various apertures. The law of the cosine for oblique rays of light was shown to be photographically valid up to inclinations of 60°. Beyond that point the intensity became less, possibly because of roughness of the film. The measures have all been made with a photographic wedge. Usually, three settings are made on each image; these are made at intervals some time apart. The average deviation of the wedge measures is about $\pm$ 0.05 magn. The wedge is capable of measuring small quantities; for example, a quantity known to be 0.03 magn. has been satisfactorily determined. One of the more important results was to show that a photographic plate is more sensitive when cold than when warm. At the same time the scale becomes less, so that the characteristics of a cold plate are changed to those of a faster emulsion. This is of special importance in winter, when plates may be taken from a warm dark-room and exposed in zero weather. It is the practise here to have all holders loaded in a cold outer dark-room, or left outside long enough to assume the external temperature before exposure. The effect of humidity is to decrease the sensitiveness. The so-called "time correction" has been investigated, and found to vary with the density of the image, the character of the developer, and other similar conditions. The light of the moon, sun and several planets has been determined. The light of the sky has been measured from noon to ten o'clock in the evening. The difference in brightness from day to night is about 17 magnitudes. The decrease at twilight is very rapid, amounting to 10 magnitudes in an hour. The measures of the bright stars have yielded perhaps the most important result, the relation of photographic and photometric magnitudes to the class of spectrum. The curve given in Vol. 59 of the *Harvard Annals* was based on about 110 stars. During the past year a redetermination of the magnitudes of the 33 stars discussed in No. 4 of Vol. 59 has been made. A supplementary list also has been observed, which brings the number of stars to 153. The latest results are included in the figure exhibited. These values give the means of finding the photographic magnitude with considerable accuracy, when the photometric magnitude and the class of spectrum are known. The average deviation of the individual stars from the curve is about $\pm$ 0.10 magn.

The method of obtaining magnitudes by photographing stars out of focus has been safeguarded so that there is little chance of grave error, except as may be caused by a change of conditions occurring during the period of exposure of any plate. This is in part eliminated by requiring that five measures of each star shall be made on five different nights. The distance at which the plate is set from the focal plane precludes the possibility of error arising from slight changes of focus. Since the approximate photographic magnitude is known in advance, it is possible to obtain images that match closely those of Polaris in density, thus making the scale of the plate of less importance. The method thus far used makes one exposure necessary for each star. Work on the Pleiades has been begun, using a brass plate having a number of apertures in it, so that each star shines through its own individual window to illumine the sensitive plate. Thus, a number of stars may be photographed simultaneously. Preparations have been made also to apply the method of out-of-focus images to the region of the pole. In order to obtain fainter stars the plate will be very near to the focal plane, and settings will be made inside and outside the focus in order to correct for change of focus, lack of flatness of the plate, and like sources of error. The great advantage of all these methods is that they give absolute values, and are free from many of the errors that usually beset photographic work.

A Unique Perturbation of Neptune: W. H. PICKERING.

An examination of comet orbits led the author to suspect the existence of a large dark unknown body, located not far from the sun and in the general direction of the north pole of the ecliptic. Such a body should produce a peculiar perturbation of the outer planets, forcing them to describe smaller circles of the sphere, slightly to the south of their assumed orbits. To determine if this were the case a study has been made of the orbit of Neptune, based on the observations made at Paris and Greenwich. It was shown that from 1846 to 1873 the observations were well represented by Le Verrier's orbit and from 1882 to 1897 by that of Newcomb, but that Le Verrier's orbit would not represent the later observations nor the orbit of Newcomb the earlier, and sys-

tematic errors in latitude of from 1″ to 2″.5 were shown to exist in each case. Furthermore, it was demonstrated that it was impossible to represent both series of observations by any great circle. Since 1897 the planet has deviated farther and farther to the south from both of the computed orbits. The least deviation from the great circle, which would account for all the observations, was 1″, but a deviation of 2″.2 gave more concordant results. Uranus also gave indications of motion in an orbit well to the south of the great circle, but the deviation was too small both theoretically and practically to have much weight.

On the Light-curve of R T Persei: R. S. DUGAN.

The discussion of 14,000 photometric settings being nearly in final form, the following conclusions can be drawn: (1) The period is changing. (2) The apparent slight asymmetry of the light-curve is probably real. The greater part of this asymmetry is due to a cause other than eccentricity of orbit. (3) At the beginning and end of eclipse, the simple geometrical representation of the curve is a little unsatisfactory.

The Spectra of some Close Double Stars: ANNIE J. CANNON.

A large number of peculiar spectra are described in volumes 28 and 56 of the *Harvard Annals*. Forty-six of these were classified as composite, eighteen of which were found by Miss Maury. These composite spectra may be divided into two groups, according as the brighter spectrum is of an earlier or later class than the fainter. In thirty-two cases, the spectrum resembles that of a second or third type star, except that $H\delta$ and $H\gamma$ are more intense and the band K, due to calcium, is fainter than normal. The two wide absorption bands, K and H, at wave-lengths 3934 and 3968, are marked features of classes G to M in spectra photographed with the objective prism. K is as wide, or wider than, H and any decrease in its intensity is readily noted. In some of these stars, as ϵ Carinæ, the band K is almost obliterated; in others, as 12 Comæ Berenices, it is about half as wide as the band H. On photographs of sufficient exposure, ultra-violet hydrogen lines $H\eta$, $H\theta$, $H\zeta$ are seen as in spectra of types B to A5. It thus appears that the hydrogen lines are intensified and the calcium band is weakened by the superposition of a spectrum, which has stronger absorption of hydrogen and little or no absorption of calcium. Ten of these stars are known visual doubles, whose companions are close enough and sufficiently bright to cause the observed peculiarity of the spectrum. Eight are spectroscopic binaries: τ Persei, γ Persei, ζ Aurigæ, α Scorpii, δ Sagittæ, 31 Cygni, β Capricorni and α Equulei. Since α Scorpii is both a visual and spectroscopic double, it is uncertain to which companion the peculiar spectrum is due. It seems probable that there are at least seven spectroscopic binaries in which the two stars have widely separated classes of spectrum. Taking the known doubles from the list, there remain fourteen stars whose companions are yet to be observed. The following nine are brighter than the magnitude 5.50: H. R. 1129, *f* Persei, ϵ Carinæ, 12 Comæ Berenices, H. R. 5667, H. R. 7031, 6 Cygni, 47 Cygni and λ^3 Aquarii. Perhaps the most interesting case is that of 6 Cygni, which is the brighter component of the well-known double star β Cygni. The visual companion, whose spectrum is of class A, is photographed apart from that of 6 Cygni and, therefore, could not be the cause of any peculiarity due to superposition. The faintness of the absorption band K in 6 Cygni is well shown in the reproduction of this spectrum in Plate XI. of the "Atlas of Representative Spectra" by Sir William Huggins and Lady Huggins. Five measures of radial velocity which have been published by Küstner show no variation. However, in this case, as well as the others, it seems highly probable that additional observations will confirm the existence of a close companion.

Publications of the U. S. Naval Observatory in Press: W. S. EICHELBERGER.

Volume VI. will contain the observations made with the equatorial telescopes from 1893 to 1907: positions of satellites, diameters of planets and satellites, double stars, asteroids, comets, occultations, phenomena of satellites of Jupiter and Saturn, and transits of Mercury. This volume will also contain several appendices, as follows: the mass of Titan, the orbits of Deimos, Phobos and Enceladus, the solar parallax from observations of Eros, eighteen asteroid orbits, twelve comet orbits; miscellaneous observations of the transit of Mercury in 1894; and a catalogue of the publications of the Naval Observatory. Volume VII. will be a catalogue of the Washington Zones, 1846 to 1852, embracing about 45,000 observations on 23,518 stars. About 38,000 of these were reduced by nights and published thirty years ago; the remaining 7,000 now appear for the first time and a systematic search has been made for errors in the earlier reductions.

Solar Disturbances and Terrestrial Temperatures: W. J. HUMPHREYS.

Observations appear to show that earth temperatures are greatest at times of sun-spot minima and least during spot maxima, and the natural inference is that there must be at these times corresponding differences in the solar constant, though such differences have not yet been observed through a spot cycle. At the time of spot maxima the solar corona is most extensive, and this must lead to a maximum in the scattering or diffusion of the radiation, and therefore to a minimum in the amount of short-wave light that reaches the earth, even though the total energy output may be the same. Now a change in the violet and ultra-violet radiation that reaches the cold dry oxygen in the upper atmosphere presumably alters the amount of this oxygen that exists in the form of ozone, in the sense that the greater this ozonizing radiation the greater the amount of ozone. Further, since ozone absorbs earth temperatures far better than the shorter wave-length solar radiations, it follows that when the ozone is in greatest abundance, or, as appears from the above, during spot minima, there must be an increase in earth temperatures. Temperature changes, therefore, that seem to indicate variations in the solar constant may be caused in part by changes in the spectral distribution of the sun's energy.

On the Solar Spectrum; Considerations based on a Study of Rowland's Tables: H. F. NEWALL.

On the Variations of the Cyanogen Band at Wave-length 3883: H. F. NEWALL.

Progress in Visual Observations of Variable Stars at the Harvard College Observatory: LEON CAMPBELL.

The regular monthly observation of seventeen circumpolar variables of long period was begun in 1888. Sequences were selected, estimated and measured, and accordingly the magnitudes of the comparison stars were deduced on a uniform photometric basis. In 1892, fifty-six more variables, mainly of long period, were added to the list, and sequences for these were treated in a similar manner. Observations were made of these variables first by the method of Argelander and more recently by the method of direct estimates. The results of these observations up to 1906 are given in volumes 37 and 57 of the *Harvard Annals*. In 1904 the observing list was extended to include nearly all the variables of long period north of declination —25°, having a maximum brightness of 9.0 or brighter, and with a range of at least three magnitudes. More recently the above scheme has been extended to the southern sky, and over a hundred stars are included. For the ready and accurate identification and observation of these four hundred and more variables, maps have been made by enlarging sections of the charts of the Bonn Durchmusterung and photographs taken at this observatory; the excellent series of charts of Hagen and of the Yerkes Observatory have also been used. Twenty years ago an evening's work consisted of 15 to 20 observations, whereas now 50 and occasionally 75 are made; and the total number per annum has increased fivefold.

A Comparison of Magnitudes of Certain Stars in the Oxford and Potsdam Astrographic Catalogues and in the Cape Photographic Durchmusterung with Magnitudes on the Harvard Standard Photographic Scale: H. S. LEAVITT.

Photographs and Spectrum of Halley's Comet: A. FOWLER.

The photographs exhibited were taken by Mr. Evershed at Kodaikanal, India, the spectra having been obtained by the use of a prismatic camera of 2 inches aperture and 11½ inches focal length, with two prisms of 60°. The continuous spectrum of the nucleus crossed by Fraunhofer lines was clearly shown, together with the gaseous spectra respectively characteristic of the head and the tail. Fraunhofer bands of carbon and cyanogen were the chief features of the head, that of cyanogen at λ 3883 being especially intense, while the bands of the tail were essentially the same as those which appeared in Comets Daniel (1907) and Morehouse (1908). The author gave an account of the experimental work which had led him to identify the bands of the tail with the spectrum of carbon monoxide at very low pressures, and also to explain certain peculiarities in the carbon bands in the head by the superposition of a newly recorded "high-pressure" spectrum of the same gas.

Recent Results concerning Encke's Comet: OSKAR BACKLUND.

Wave-length Formulæ for Series of Lines in Spectra: J. RYDBERG.

Meteorological Observations in Connection with Halley's Comet: W. J. HUMPHREYS.

This is a summary, made by Dr. Humphreys at the request of the comet committee of the society, of the atmospheric and other meteorological phe-

nomena at and around the time that Halley's comet was in transit on the sun, in this country and the West Indies. The chief material for this summary is the responses to a circular letter issued by the chief of the Weather Bureau to nearly two hundred of its observers. No magnetic or electric phenomena were noted that could reasonably be attributed to the comet. At many places, however, parhelia of unusual brilliancy and general appearance were seen; concerning these Dr. Humphreys concludes that "at present the possibility of the comet's influence in producing them can not be definitely excluded."

Report of the Committee on Luminous Meteors: CLEVELAND ABBE (chairman).

The chairman reported that, owing to his removal from Baltimore to Mount Weather, he had not been able to construct the apparatus for continuous photographic registration of the paths and times of bright meteors that pass within 45 degrees of the zenith. But this he expects to accomplish during the next year. The urgency of this class of work has been materially increased by recent theoretical memoirs on the composition, temperature and motions of the upper atmosphere. The success of such apparatus is assured by the recent work of Störmer, who has succeeded in obtaining a continuous series of instantaneous photographs of any portion of the aurora borealis at two neighboring stations; whence the altitudes are accurately determined just as it is expected to do in studies of meteors.

Report of the Committee on Comets: GEORGE C. COMSTOCK (chairman).

The work of this committee during the year has been concerned with observations of Halley's comet. The best methods of utilizing the present return were discussed by the committee and their conclusions were embodied in a circular letter that was widely distributed. The committee secured a grant of $2,200 from the Bache Fund of the National Academy of Sciences to defray the expenses of temporarily installing a photographic telescope in the Hawaiian Islands. Mr. Ferdinand Ellerman had charge of this expedition, and for this purpose he was courteously granted leave of absence by the Carnegie Institution. The committee is further indebted to the John A. Brashear Company and to the Lick Observatory for the loan of the portrait lens and its mounting. Mr. Ellerman succeeded in securing an extremely valuable record of the comet's appearance. He also made careful observations of the sun at the time when the comet transitted its disc, with wholly negative results, as was also the case at all other stations. Although the chances of success seemed small, the United States Weather Bureau undertook to secure from its observers reports as to any unusual atmospheric phenomena observed during or near the time that the earth was supposed to be passing through the comet's tail. For Dr. Humphreys's summary of these reports, as well as Mr. Ellerman's account of his activities in Hawaii, see their papers above.

The bill that is now pending in congress contemplating the appointment of a civilian head to the United States Naval Observatory was the subject of discussion both in the meetings of the council and in the general sessions of the society; as a result it was unanimously

Resolved: That the Astronomical and Astrophysical Society of America, deeming it essential to the success of an astronomical observatory that it should be under the direction of an eminent astronomer, expresses its appreciation of the efforts of the President of the United States to secure at the United States Naval Observatory this condition that has been found so effective in the great national observatories of other countries.

The officers elected for the ensuing year are: *President*, E. C. Pickering; *First Vice-president*, G. C. Comstock; *Second Vice-president*, W. W. Campbell; *Treasurer*, C. L. Doolittle; *Councilors*, W. J. Humphreys and Frank Schlesinger.

In response to a cordial invitation from Chief Astronomer King, it was decided to hold the next meeting at the Dominion Observatory in Ottawa, at some time next summer, the exact date to be fixed later by the president and the secretary.

Immediately after the close of the meeting many of those present started together on a journey across the continent for the purpose of attending the meeting of the Solar Union at Pasadena.

FRANK SCHLESINGER,
Editor for the Eleventh Annual Meeting

SOCIETIES AND ACADEMIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

THE 683d meeting of the society was held on November 5, 1910, President Woodward in the chair. The following paper was read:

On Gravity Determination at Sea: Dr. L. A. BAUER, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.